JOHN GLENN WORKING PAPER SERIES

Do High Technology Policies Work?
An Analysis of High Technology Industry Employment Growth in U.S. Metropolitan Areas, 1988-1998

J. Craig Jenkins

Kevin T. Leicht

Arthur Jaynes

Forthcoming Social Forces June 2006.

Working paper 2005-4
December 14, 2004
http:://kb.osu.edu

The John Glenn Institute for Public Service and Public Policy
And
The School of Public Policy and Management

Page Hall
1810 College Road
The Ohio State University
Columbus Ohio 43210-1336

We have benefited from the advice of Ed Malecki, Don Haurin, Bill Form, Randy Hodson, Rachel Dwyer and participants in seminars at the Center for Urban & Regional Affairs and the Dept. of Sociology. Jason Carmichael, Steve Boutcher and Maria McHale also provided invaluable research assistance. This project was supported by the Urban Affairs Program (Project #739365) and the John Glenn Institute for Public Policy, The Ohio State University. The views expressed herein are those of the authors and do not necessarily reflect the views of The John Glenn Institute or the School of Public Policy and Management.

ABSTRACT

In the past three decades, federal, state and local governments have launched an array of new high technology development programs. Researchers and policy-makers disagree about the relative merits of these policies as economic development tools. We address two questions: (1) Do these policies affect high technology industry employment net of location and agglomeration factors? (2) Do these policies interact with existing agglomeration advantages to boost high technology industry employment? Using a conditional change score design to examine the effects of seven major high technology policies on the change in high technology industry employment in metropolitan statistical areas (MSAs) between 1988 and 1998, we find that two programs--technology grant and loan programs, and technology research parks--have direct effects net of controls for location and agglomeration factors. All of these programs, except for SBIRs and technology development programs, positively interact with existing agglomeration advantages to create high technology industry employment growth. Technology development programs compensate for deficits in agglomeration resources. High technology growth is an organic, path-dependent process that depends primarily on location and agglomeration advantages but also can be planned by adapting high technology programs to magnify these local growth advantages.

J. Craig Jenkins,
Dept. of Sociology,
300 Bricker Hall,
190 N. Oval Mall,
The Ohio State University,
Columbus OH 43210. Email:
Jenkins.12@sociology.osu.edu.

Kevin T. Leicht
The University of Iowa

Arthur Jaynes
The Ohio State University

DO HIGH TECHNOLOGY POLICIES WORK?

AN ANALYSIS OF HIGH TECHNOLOGY EMPLOYMENT GROWTH IN U. S. METROPOLITAN AREAS, 1988-1998

Since the early 1970s, state and local governments have launched a wide array of new economic development programs to promote high technology development. Popularly called "third wave," "new industrial" and "entrepreneurial" policies, these initiatives entail direct state intervention in the creation of new enterprises, products, markets and technologies. By helping to identify market opportunities, fostering local innovation capacities, and making public investments in new technology and private enterprises, these governmental programs have attempted to promote "risky but potentially productive undertaking(s) that would not have gone forward without governmental support" (Eisinger 1988: 230). In contrast to traditional industrial recruitment incentives that attempt to attract existing enterprise by lowering labor and other input factor costs, these new initiatives involve direct governmental intervention in the creation of new technology, products, markets and enterprises. Public venture capital programs, Small Business Innovation Research (or SBIR) programs, grant and loan programs to finance the development of new technology, university-affiliated technology development centers, technology deployment/transfer programs, technology business incubators, and technology research parks are designed to create new high technology industry.

Our research addresses two questions about these programs. First, how effective are they at promoting high technology industry employment growth net of existing agglomeration and location factors? Second, do these programs magnify or compensate for agglomeration and location factors, including existing high technology industry?

We take a regional perspective by examining the growth of high technology industry employment in metropolitan areas (MSAs) in the U.S. between 1988 and 1998. Several large MSAs, like Chicago, Illinois, Washington, D.C., Boston, Massachusetts, and San Jose, California started this decade with major high technology concentrations that continued to grow. Others, like Los Angeles, California, Detroit, Michigan, and Seattle, Washington had large high technology sectors, which declined. Other smaller MSAs, like Wichita, Kansas, Austin, Texas, Dayton-Springfield, Ohio, and Raleigh-Durham, N.C., began with small high technology sectors but grew rapidly. Our major concern is whether the high technology development policies adopted by state and local governments helped create this high technology industry employment growth.

Policymakers and the general public treat employment and jobs as the central yardstick for evaluating these programs. The primary rationale for these "high tech" programs is that they create quality jobs. High technology also has significant spillover effects on the technology and growth of other industries (Hecker 1999; Hadlock, Hecker and Gannon 1991; Zachariadis 2002), and is critical to the economic competitiveness of specific regions and nations in an increasingly global economy (National Science Board 1998: Ch. 6; Fujita, Krugman and Venables 1999; Atkinson and Gottlieb 2001; Devol, Koepp and Fogelbach 2002; Harchaoui, Tarkhani, Jackson and Armstrong 2002). As we show below, wages in high technology industries are typically thirty to forty percent higher than in other industries (see also Hecker 1999). In terms of general economic growth, labor productivity in high technology manufacturing increased between 1987 and 1999 by an average of 9.5 percent per year compared to 3.2 in the manufacturing sector as a whole (Kask and Sieber 2002). High technology employment was second only to human capital as a predictor of per capita income growth in U.S. states between 1995 and 2000 (De Vol et al.

2002). High technology development is critical to the prosperity and economic competitiveness of the states and communities that have invested in these new programs. But do these high technology programs work?

DIFFERING VIEWS ON LOCATION-SPECIFIC TECHNOLOGY POLICIES

Some analysts argue that high technology development is an organic, path-dependent process that cannot be readily influenced by public policies (Kenney and von Burg 2000). Others contend that conventional location factors, such as labor and housing costs, low taxes, regulatory environments and access to transportation and markets are of limited importance (Kenney and von Burg 2000; Florida 2002). The major input factor in high technology production is scientific intelligence harnessed to technical problem-solving. Hence, in principle, high technology industry is location-free and cannot be influenced by traditional industrial recruitment incentives.

However, high technology industry is locality bound as it depends heavily on interpersonal networks and the social reinforcement of entrepreneurial activities (Florida and Kenney 1990; Saxenian 1994; Thornton 1999; Kenney and Von Burg 2000; Lee, Miller, Hancock and Rowen 2000; Florida 2002; Kolko 2002). High technology entrepreneurs and workers need access to tacit and technical knowledge as well as social reinforcement for entrepreneurial activities that are important to industrial growth in general (e.g. Sorensen and Audia 2000) and especially to growth in high technology industries (Lee et al. 2000; Koepp 2002). High technology firms tend to cluster geographically because of the need for information exchange, the interpersonal transmission of tacit knowledge about business formation and product development, localized concentrations of skilled labor, lifestyle amenities, and research facilities associated with research universities, large corporations and federal research labs

(Cohen, Nelson and Walsh 1996; Luger and Goldstein 1997; Branscomb and Florida 1998; Kenney and von Burg 2000; Kolko 2002; Goldstein and Renault 2004). Most new high technology firms are spin-offs of other high technology firms, typically located within the same immediate area as the parent enterprise. Markusen, Hall and Glasmeier (1986: 154-56) found that agglomeration effects from *Fortune* 500 headquarters, business services, and military R&D affected high technology manufacturing growth in MSAs between 1973 and 1977. Access to venture capital is critical for converting new ideas into commercial products (Kenney and Florida 2000; Thornton 1999; Florida 2002). State and local high technology programs may substitute by providing startup capital (e.g. public venture capital, SBIR funding, and technology grants and loans), technical and management advice (e.g. business incubators, research parks), informational networks (e.g. business incubators and research parks, networking programs) and, perhaps more importantly, operate as catalysts for magnifying the impact of existing location and agglomeration advantages.

Proponents of high technology policy have traditionally debated two general approaches: (1) a centrally-directed *infrastructure strategy* of investing in public research and specialized infrastructure to attract existing high technology industries to specific locations or "technopoles" (Castells and Hall 1994); and (2) a more decentralized *entrepreneurial strategy* of reinforcing local innovation capacities by investing in new enterprises and products, and promoting the development of local networks and partnerships (Eisinger 1988; Osborne 1988; Clarke and Gaile 1989, 1998). In the first approach, governments lower the costs of innovation by providing a general set of resources that (in theory) existing firms and potential entrepreneurs can take advantage of. The assumption is that if government "builds it," high technology entrepreneurs "will come." In the second approach, governments invest directly in new enterprises and technology on a competitive basis and foster networking in the hope of creating a critical mass of high-technology firms. This approach has been popularized as a "grow your own" (Osborne 1988) or entrepreneurial strategy (Eisinger 1988; Clarke and Gaile 1989, 1998).

In the U.S., federal, state and local governments have used both strategies to provide startup and intermediate financing, technical and managerial assistance for existing and would-be entrepreneurs, and provided infrastructure in the form of high technology research parks, business incubators and technology development programs. The overlap and mix of these programs suggests that, instead of viewing these as incompatible approaches, they might best be seen as complementary parts of a general high technology strategy. Public venture capital programs and SBIRs attempt to boost local innovation capacities by facilitating existing enterprises and would-be entrepreneurs. Technology development and grant/loan programs promote R&D in specific firms and industries while also increasing the overall innovation capacity and resources of specific locales through investments in university research labs and research centers. Technology deployment and transfer programs promote the adoption of "state of the art" technology. Research parks and business incubators attempt to create "technopoles" while also strengthening local innovation capacities. We want to know which if any of these policies promote high technology employment growth.

Our focus is change in high technology industry employment in MSAs between 1988 and 1998. MSAs constitute an ideal ecological unit for evaluating these policies as well as underlying location and agglomeration advantages. In 1990 an MSA was defined as an integrated labor market within a one-hour commute of a central city of 50,000 or more population. By mapping the location of federal, state and local high technology programs to these MSAs, we evaluate whether these programs had an impact net of existing location and agglomeration advantages and whether these programs magnify or compensate for these local growth factors. Several location and agglomeration factors, such as major air hubs and federal R&D expenditures, are likely to have benefits that operate on a larger ecological scale than cities or counties, pointing to the advantage of a focus on MSAs.

We examine decade-long change because most high technology programs, regardless of their specifics, are focused on the startup or intermediate phases of product development. Product development typically requires at least 5 to 10 years to move from an initial business proposal to actual production on a scale that would measurably affect employment.

We begin with a discussion of the nature of high technology industry and its distribution across MSAs.

HIGH TECHNOLOGY EMPLOYMENT IN METROPOLITAN AREAS, 1988-1998

High technology industry is generally defined in terms of "the design, development, and introduction of new products and innovative manufacturing processes, or both, through the systematic application of scientific and technical knowledge" (U.S. Congress, Office of Technology Assessment, 1984: 8-9). Such enterprises produce sophisticated products, use advanced or state-of-the-art techniques, have high expenditures on research and development, and employ a disproportionately large share of scientific, technical and engineering personnel.

What is High Technology Industry?

Analysts have taken two general approaches to measuring the growth of high technology industry. An *output approach* focuses on the technical sophistication of an industry's product or the extent to which products have undergone rapid change. The Bureau of the Census (National Science Board 1998: 6.12-6.13), for example, used the expert judgment of industry analysts to identify leading-edge technologies in ten product areas. Most popular accounts of high technology industry (e.g. Kotkin 2001) rely on similar criteria. However, there is little agreement on what constitutes a sophisticated product and there is no clear way to link such products to employment change.

A second approach is to focus on *inputs* to industries by examining the proportion of workers in technology-oriented occupations or the business costs devoted to research and development. This approach provides objective criteria and has a direct link to employment data. Markusen et al. (1986) identify high technology manufacturing as industries that exceed the manufacturing mean in the percent of scientific, technical and engineering personnel in 3-digit SIC industries. Hadlock, et al. (1991) improve on Markusen et al. (1986) by using the Occupational Employment Statistics Survey (or OES) of private employers to identify the proportion of technology workers engaged in research and development.

We use Hecker's (1999) refinement of Riche, Hecker and Burgan's (1983) and Hadlock, et al's (1991) approach that has three main advantages.[1] First, it uses newer OES estimates of scientific and technical personnel. Second, it uses a more stringent "input" criterion of having at least twice the industrial mean in *both* employment in research and development *and* employment in all technology-oriented occupations. Third, it includes services as well as manufacturing, which is critical in view of the growing significance of high technology services. "High technology" is thus defined as all private sector industries where employment in *both* research and development *and* in all technology-oriented occupations is at least twice the industrial mean. We use Hecker's estimates, which rely on the 1987 OES. The OES covers all industries except agriculture (minus agricultural services), forestry, fishing, private households and the Federal government. Although the exact cutoff for "high" vs. "non-high tech" industry is ultimately arbitrary, Hecker's definition provides a conservative objective basis for gauging industrial employment trends. At the MSA level, it also overlaps closely with the industry lists used earlier by Riche, Hecker and Hadlock (1983), Markusen et al. (1986), and Hadlock, et al. (1991).[2]

We examine the first difference change in private sector employment at the MSA level in the thirty-one 3-digit SIC industries identified by Hecker (1999). To measure this, we use the Current Employment Statistics Survey (or CES), compiled by the Bureau of Labor Statistics from Social Security establishment unit reports (also known as the ES-202 program), which provides the most reliable available estimate of private sector employment at the 3-digit SIC level. Four of our high technology industries are in services and twenty-seven are in manufacturing.[3] In 1988, there were 6.6 million high technology industry jobs inside of MSAs, representing 74.6 percent of the national total of 8.8 million high technology industry jobs. By 1998, high technology industry employment inside of MSAs grew to over 6.9 million jobs but, reflecting the region diffusion of high technology industry, this constituted only 67.6 percent of 9.8 million national high technology industry jobs. Moreover, the high technology share of jobs in MSAs declined from 9.2 to 7.9 percent of total private sector MSA employment, reflecting the more rapid employment growth in other industries. Nonetheless, high technology industry continued to be a source of "good jobs." In 1988 the mean wage for high technology industry jobs was $29,046 (in 1988 current $U.S.), which was 48.0 percent greater than the mean private sector wage of $19,628. In 1998, this high technology wage premium had declined slightly to be 36.3 percent greater than the mean private sector wage ($42,892 in current 1998 $U.S. for high technology industry vs. $27,329 for all private sector jobs).

We analyze the 291 MSAs for which CEW employment data are available for both 1988 and 1998. In 1990, an MSA was defined by the Census Bureau as an integrated labor market within a one-hour commute from a central city with at least 50,000 population (Bureau of the Census 1991). Due to Census revisions in the MSA list between 1980 and 1990, high technology industry employment estimates are not available for 22 MSAs. Eight of these MSAs were removed from the 1980 Census list and the other fourteen MSAs were new additions. Our 291 MSAs contain 97.04 percent of the 1990 U.S. Census estimate of the national metropolitan population and provide the most complete set of reliable estimates of change in MSA employment available.[4]

Table 1 identifies the top 20 MSAs in terms of the growth of additional high technology industry employment between 1988 and 1998 and the top 20 MSAs in terms of the loss of high technology industry employment. In contrast with the conventional wisdom that advantaged high technology areas experienced greater growth in new high technology jobs, the percent of employment linked to high technology industry in 1988 is negatively correlated with the change in high technology industry employment between 1988 and 1998 ($r = -.144$, $p < .014$). This indicates a trend toward the dispersion of high technology industry employment and a convergence among MSAs in terms of the presence of high technology industry (for the parallel convergence in the information-technology sector, see Kolko 2002). As noted earlier, some MSAs, like San Jose, California and Washington, D.C., are high technology "meccas" that had major concentrations of high technology industry in 1988 and experienced further high technology industry employment growth during the 1990s. Others, like Los Angeles, California, Detroit, Michigan, and Seattle, Washington had large high technology sectors but experienced significant loss in high technology industry jobs. Why?

(Table 1 about here)

OTHER EXPLANATIONS FOR HIGH TECHNOLOGY EMPLOYMENT GROWTH

Location Theory.

While our major interest is the effect of high technology development programs, other explanations need to be included. Analysts of regional development have traditionally focused on *location advantages* and *agglomeration effects*. Location explanations suggest that lower input factor costs (such as wages or taxes) and central location advantages, such as access to transportation and markets, facilitate economic development. Irwin and Kasarda (1991) show that centrality in the airline industry hub system contributed to economic growth and, given the importance of rapid transit to high technology industry, we would expect airline access to facilitate high technology development. Similarly, central access to markets as gauged by greater population density and interstate highway access should boost high technology development. Markusen et al. (1986: 155) found that a favorable climate, airline access, and educational options in terms of the number of 4-year higher education institutions contributed to high technology industry employment growth between 1973 and 1977. They also found that an increased percentage of blacks in an MSA discouraged high technology industry employment growth, which they interpreted as reflecting racial prejudice and human capital deficits. Other location factors, such as higher mean wages in high technology industry and recreational and arts amenities were not statistically significant.

Agglomeration Theory.

Many argue that location factors are of little importance for high technology industry and that agglomeration processes are more important. Due to the labor-intensive nature of high technology production and the importance of tacit knowledge (Saxenian 1994), these firms are unlikely to achieve internal economies of scale but may achieve external economies of scale by building business partnerships and extensive interpersonal networks among distinct firms to exchange technical and market information (Kenney and Von Burg 2000). Numerous case studies of particular high technology industries and regional high technology clusters indicate the importance of entrepreneurial resources (such as venture capital) and a pattern of corporate spin-offs, inter-firm personnel transfers, and collaborative business partnerships (Rogers and Larsen 1984; Saxenian 1994; Thornton 1999; Kenney and Florida 2000; Lee, et al. 2000; Cortright and Mayer 2002). Markusen et al. (1986) found that military R&D facilities contributed to high technology industry job growth along with concentrations of business service firms, such as accounting, legal and public relations firms. Although many note that high technology development has been greater outside the older more dense cities that were the urban centers for earlier industrial development, human ecologists argue that greater population density sustains high rates of social interaction and specialization, thereby promoting social and economic innovation (Hawley 1981). This innovation capacity should support high technology development. We therefore include population density as an agglomeration factor as well as a locational advantage.

Technology Policy as a Multiplier?

Federal, state and local entrepreneurial programs are designed to compensate for or to reinforce agglomeration processes. Several studies have examined the effects of particular high technology policies but typically without comparing units with and without these policies. Luger and Goldstein (1991) found that over half of the high technology parks founded between 1950 and 1989 failed in the early stages and, of those that survived, less than half generated significant total employment growth in their immediate region (mostly older parks affiliated with major research universities that had more comprehensive service programs). But they did not compare counties without parks to those with parks, leaving unclear the distinctive contribution of parks to employment growth. Moreover, a more relevant outcome measure would have been high technology industry employment. Yet this study did point to the possible importance of proximity and ties to research universities as magnifying the effects of these parks. In a study of biotechnology patents, Cortright and Mayer (2002) found that university and federally funded biomedical R&D contributes to commercialized knowledge in MSAs that also have significant concentrations of private venture capital. In other words, it is the *conjuncture* of biomedical R&D *with* private venture capital that leads to biomedical patents. Most university and federal research does not lead to patents but the existence of favorable university policies and local venture capital appear to be important contextual factors. Audretsch, Weigand and Weigand (2002) show that SBIR programs in Indiana provided small enterprise financing for a significant number of new high technology enterprises that otherwise were unlikely to have been created. All of these studies have the major limitation that they did not compare ecological units with and without programs, leaving unclear the distinctive impact of high technology policies.

Two prior studies of state government high technology programs provide inconclusive results. Leicht and Jenkins (1994) found that state high technology policies contribute to new firm formation but did not increase manufacturing employment, economic growth or reduce unemployment. Saiz (2001) found that these programs contribute to manufacturing employment but did not influence economic growth, service sector employment or reduce unemployment. While there are slight differences in time periods and modeling methods, the major difference between these studies is the measurement of high technology policy. Leicht and Jenkins (1994) use a latent construct based on a confirmatory factor analysis of the presence of five major programs, while Saiz (2001) uses summative scales based on the high technology attributes of state development programs described in multiple editions of The Directory of Incentives for

Business Investment and Development in the United States. However, the Directory does not list most high technology programs, which are better documented in the specialized reports used by Leicht and Jenkins (1994) and the reports we cross-classify here. Both studies deal with only a short time period of 2 to 5 years to gauge employment change when a decade or more would be more appropriate, and neither study examines change in high technology industry employment.

We examine seven programs that have been initiated by federal, state and local governments over the past three decades to promote regional high technology development. First, *public venture capital* programs provide startup, intermediate and commercialization financing for new products and firms. While the specific financing terms vary widely, these programs put state government in the position of taking a royalty or ownership position in new products and enterprises. Some investments create equity shares in a private stock company or royalty claims against the sales of particular products. Others are convertible into long-term bonds. In the case of a business failure, some investments are converted into grants with no repayment obligation while others remain liabilities resolved in bankruptcy proceedings.

Second, *Small Business Innovation Research* programs (or SBIRs) require federal agencies that make grants for technology innovation to set aside a specified portion for small business. Local SBIR programs chartered by state governments administer these grant programs and, over the past two decades, have become a significant source of federal funding for new enterprise development (Wallsten 1998; Audretsch, et al. 2002).

Third, *technology grant and loan programs* provide financing for the development of new products, typically through a competitive application process where would-be entrepreneurs provide business plans for the commercialization of specific products. We include in this category tax subsidized private venture capital firms, Business Investment Development

Companies (BIDCOs), and commercialization programs that rely exclusively on grants and loans.

A fourth approach is *technology development programs*. Typically associated with research universities and government-industry consortia (e.g. Sematech), these programs focus on basic and applied research to develop new products and technology. Some are funded directly to operate research programs while others are funded by federal and state grants and contracts to develop new technologies and products.

Fifth, *technology deployment and transfer programs* focus on the utilization of "state of the art" technology. Taking land grant university rural extension programs as their historical model, these programs focus on the transfer and deployment of existing "state of the art" technology through consulting, customized labor training, technical reports, conferences and symposia. Some programs are administered as state agencies while others are organized as nonprofit corporations. Technology deployment and transfer programs typically deliver services through contracts and direct delivery.

Sixth, *high technology business incubators* provide subsidized space for research and development and, in varying degrees, technical and business advice, including assistance in securing public and private financing. Some incubators are state or local governmental agencies, others are affiliated with research universities, two-year colleges, and research parks, while others are independent nonprofit and for-profit corporations. Incubators often have multiple sponsors, including federal agencies and private corporations as well as state and local government. We include only business incubators with state and local government sponsors that have a declared high technology focus.

Finally, *technology research parks* provide subsidized long-term space for high technology businesses along with varying degrees of business financing and managerial/technical assistance. Most are affiliated with research universities and typically operate as state-chartered nonprofit corporations. Both business incubators and research parks typically specialize in particular technologies, attempting to foster local expertise, partnerships and networks.

Our earlier distinction between an infrastructure and an entrepreneurial strategy should be conceptualized as a continuum. Business incubators, research parks and technology development programs lie on the more centralized end, attempting to foster high technology agglomeration by subsidizing research and development costs in specific locations. In comparison, public venture capital, SBIRs, technology grant and loans, and technology deployment/transfer programs lie more on the entrepreneurial end, attempting to respond to existing enterprises by strengthening existing local innovation capacities. However, as noted above, these strategies are often operationally combined with (for example) research parks operating their own venture capital and SBIR initiatives and entrepreneurial programs favoring local firms.

Capturing State and Local Technology Programs

Table 2 summarizes the counts of these state and local technology programs that were operating in metropolitan and non-metropolitan areas in 1990. We derived information on these programs from the comprehensive listing of state government technology programs compiled by the Carnegie Commission on Science, Technology and Government (Coburn and Berglund (1995), Luger and Goldstein's (1991) list of technology research parks in 1990, Eisinger's (1991) list of public venture capital programs in 1989-90, the 1990 membership list of the

National Association of Business Incubators (1990), Clarke (1986) inventory of state technology programs for the National Governor's Association, the inventory construction by the Minnesota Dept. of Trade and Economic Development (1988), the Directory of Incentives for Business Investment and Development in the United States published by the National Association of State Development Agencies (1986, 1991 and 1994), and a comprehensive review of the websites of all state technology development agencies (http://www.ncscienceandtechnology.com/External_Programs.htm). In 1990, business incubators were the most numerous with 137 located inside of MSAs, followed by 99 research parks, 94 technology development programs, and 77 technology deployment/transfer programs. Roughly two-thirds of these programs were located inside metropolitan areas with the remainder in non-metropolitan areas. There were significantly fewer public venture capital, SBIR and technology grant and loan programs, reflecting the fact that state governments typically establish only one headquarters office in or near the state capital.

(Table 2 about here)

To gauge the effects of these programs, we use the cumulative years' duration of each type of program in each MSA. As Wolman and Spitzley (1996) argue, it is important to move beyond measuring the simple presence of programs to capture policy scale. To gauge the scale of these programs, we summed the total years of existence of each program type within each MSA as of 1990. If an MSA had multiple, e.g., technology incubators, then we summed the total years of existence for all such programs as of 1990. While it would be ideal to have measures of the cumulative funding for these programs and other program details, such data are not available and would be near impossible to collect reliably. A poorly funded but long-term program might have little impact but, in general, programs with longer duration have likely succeeded in mobilizing more resources.

Table 3 identifies the top 10 MSAs in terms of their cumulative years of experience with each of these seven high technology programs as of 1990. Some MSAs, such as Boston, MA and Albany, NY have longstanding public venture capital programs. Minneapolis, MN leads in SBIR experience, Little Rock, AR and Boston, MA in technology grant and loans, Raleigh-Durham, NC in technology development, Augusta, GA in technology deployment/transfer, and Philadelphia, PA in technology business incubators and research parks.

(Table 3 about here)

Table 4 lists the top 20 MSAs in terms of the sum of all program years of experience. Raleigh-Durham, NC is the leader, with over 152 cumulative years of high technology program experience, followed by Philadelphia, PA (125 years), Augusta, GA (116 years) and Pittsburgh PA (81 years). The mix of these programs varies significantly, with Raleigh-Durham having more technology development and deployment/transfer programs and Philadelphia having more incubator and research park experience. Over 54 percent of all our 291 MSAs have at least one year of program experience and 27 of our MSAs had 5 or more high technology programs operating in 1990. We now turn to our method for analyzing the effects of these programs and location/agglomeration advantages on the growth of high technology industry employment.

(Table 4 about here)

METHOD AND DATA

***Model*.**

The main question facing policy makers is how to generate high technology industry employment net of existing employment levels. To address this, we use a conditional change design (Finkel 1995: 6-9) in which the dependent variable is the first difference change in the number of high technology industry jobs, which is regressed on the lagged endogenous variable (i.e. high technology industry employment in 1988) and a set of additional independent variables. There are also theoretical reasons for this design. The initial starting point of high technology industry employment is likely to affect subsequent change, either facilitating growth due to the location and agglomeration advantages associated with existing high technology industry or, alternatively, by capturing factors (e.g. diffusion, overbid wages) that geographically disperse high technology employment over time. This design also reduces the vulnerability to serially correlated measurement errors, which should be captured by the lagged endogenous term. We measure independent variables at the starting point or as near as possible with one exception—contemporaneous population change—which is introduced as an exogenous control variable.

Our model is as follows:

$$(Y_{t2} - Y_{t1}) = \_{0} + \_{1} (Y_{t1}) + \_{2} (X_{t1}) + \_{3} (Z_{t2} - Z_{t1}) + \ldots + \_$$

where $Y_{t2} - Y_{t1}$ represents the first difference change in high technology employment, Y_{t1} is high technology employment in 1988, X_{t1} independent variables measured at or near 1988, $Z_{t2} - Z_{t1}$ independent variables that changes concurrently over the period in question (i.e. 1988-1998), and _ is an error term.[5] To capture the contextual effects of policies in favorable agglomeration contexts, we also add to this equation interactions between policy measures and agglomeration variables net of the respective main effects of said policies and agglomeration variables.

We first control for location and agglomeration factors and then add the cumulative years for each type of high technology program. High technology programs need time to generate significant employment. We therefore use the cumulative years of program experience for each policy type through 1990. We address two key questions about these policies: (1) Do high technology policies have a direct impact net of location and agglomeration factors? (2) Do these policies magnify local agglomeration processes? These programs often are presented as substituting for agglomeration factors by growing new industries and employment in areas that previously lacked them. This should be indicated by significant positive effects of policy scale net of controls for location and agglomeration factors. Programs are also seen as magnifying local innovation capacities. This should be evident from positive interactions between agglomeration contexts (including existing high technology industry employment) and policies.

Measurement.

Table 5 provides a correlation matrix and descriptive statistics for all our variables. As discussed above, our dependent measure is the first difference change score in the number of private sector high technology industry jobs between 1988 and 1998. The mean change in high technology industry jobs is 2,277.8. As noted, this measure has the greatest salience to policy-makers and the general public for evaluating high technology policies. High technology industry employment in 1988 is introduced as a lagged endogenous control throughout. Both employment measures are moderately skewed, as are several of our independent measures. We also tested models using natural log transformations of all independent measures skewed 3.0 or more and obtained the same significant predictors. We present the unlogged results because they provide interpretable partial slopes indicating the number of jobs created by specific independent variables as well as interpretable adjusted R^2 statistics.[6]

(Table 5 about here)

To capture location factors that may be attracting high technology industries, we use the following: (1) the *1988 mean wages* of high technology industry jobs; (2) *median housing costs*; (3) *climate quality*; (4) *recreational amenities*; (5) *arts amenities*; (5) *airport access* (the number of daily air flights); (6) *freeway access* (the number of federal interstates highways in the metropolitan area); (7) market centrality based on *population density* in 1990 (U.S. Bureau of the Census 1991); (8) *higher education options* (the number of 4-year colleges and universities); and (9) the *percentage black population*. Mean high technology industry wages are derived from the CES data, and population density and the percent black from the U.S. Bureau of the Census (1991). All other measures come from Boyer and Savageau (1989).

Agglomeration advantages are measured by: (1) *population density* in 1990 (U.S. Bureau of the Census 1991); (2) the number of *Fortune 500 manufacturing headquarters* (1989); (3) the number of *private venture capital corporations* in 1987-88 (Morris and Isenstein 1989); (4) *university R&D expenditures* for 1990 (based on the earliest available data on the top 100 universities in terms of R&D expenditure in the National Science Foundation's (2002) WebCASPAR database: www.nsf.gov/sbs/srs); and (5) *federal and military research facilities* (as gauged by the mean of the 1980 and 1990 square meters of research space operated by the Defense Dept., NASA, NIH and the nuclear arms labs [Hooks 2003]). As noted earlier, we include population density in both location and agglomeration equations since it taps both dimensions. To capture exogenous uncontrolled growth factors, we also introduce *percent population change* between 1990 and 1997 (U.S. Bureau of the Census 2000). We use two-tailed tests of significance and inspect all equations for multicollinearity using variance inflation and tolerance statistics, finding no evidence of problems.

We also tested for influential outliers by identifying MSAs with a standardized residual of 3.0 or more and the use of standard outlier diagnostics (Bollen and Jackman 1985) applied to the full Model 6 in Table 6. This identified five outliers as potential influential cases. Detroit Michigan proved to be an influential case with respect to technology development programs.[7] We therefore remove Detroit from the regression results shown below, making our regression sample 290. We also added a set of dummy variables representing the U.S. Census regions to our full model 6 to test for omitted variables. None of these regional dummy variables were statistically significant. How do these factors affect high technology employment change?

RESULTS

Our main regression results are presented in Table 6. The lagged endogenous control is not significant (Model 1), indicating little effect of the startpoint number of high technology industry jobs. The adjusted R^2 of .001 provides a baseline for comparing subsequent models.

(Table 6 about here)

In Model 2, the lagged endogenous term, mean high technology wages, a favorable climate and the number of daily air flights are significant predictors in the predicted direction. This suggests that wages are encouraging the dispersion of high technology industry. The number of 4-year colleges and universities is significantly negative, the opposite found by Markusen et al. (1986: 155). We suspect this reflects the fact that the majority of these schools are liberal arts colleges with little direct impact on high technology development. It may also reflect the post-1960s growth in higher education where 4-year colleges are no longer critical amenities, especially relative to research universities. Later we introduce the more meaningful university R&D measure. Population density is not significant. Percent black is also not significant, suggesting that the industry avoidance of larger minority populations earlier found by Markusen et al. (1986: 155) may have dissipated. We substituted a percent Hispanic and percent black/Hispanic measure for our measure of percent black but neither effect was statistically significant. Location factors contribute 18.7 percent to explained variance (adjusted R^2 = .188) over the baseline model.

Model 3 controls for agglomeration factors, showing that, in addition to a negative effect of the endogenous lag term, *Fortune* 500 headquarters, university R&D, and military R&D positively affect change in high technology industry employment. These effects point to the importance of entrepreneurial resources and public sector R&D investments and resemble Markusen et al.'s (1986: 154-56) findings that large manufacturing corporate headquarters and military spending contribute to high technology employment growth. Population density and private venture firms are not significant. In Model 4 we add population change, which is positive and significant but does not alter any of the other factors. This suggests that other factors associated with population growth do not alter the effects in Model 3. The agglomeration factors in Model 3 add 17.9 percent in explained variance over the baseline model.

Model 5 examines the effects of our policy measures. In addition to the negative effect of the endogenous lag term, technology grants and loans, business incubators and research parks contribute to high technology industry job growth. Public venture capital, SBIRs, technology development and technology deployment/transfer programs are not statistically significant. Programs associated with both the infrastructure (business incubators, research parks) and entrepreneurial strategies (technology grants and loans) are effective at promoting high technology employment growth. At the same time, these results raise questions about the efficacy of the other four programs. We also obtained the same pattern of significant factors using simpler models with each policy measure introduced individually along with the endogenous lag term (results are available from the authors). Compared to the baseline model, high technology policies added 10.0 percent to explained variance.

Model 6 combines all the significant location and agglomeration variables with the seven policy measures to see whether high technology development policies affect high technology employment growth net of location and agglomeration factors. In addition to the location and agglomeration factors, technology grants and loans and research parks have positive independent effects on high technology industry job change. The partial slopes in this equation indicate that each additional grant and loan program year creates 2,666 high technology jobs and each additional year of research parks creates an additional 364 high technology jobs. Business incubators lose significance due to a moderate correlation with *Fortune* 500 headquarters (r = .39). When *Fortune* 500 headquarters are removed from this equation, the incubators effect is positive and significant (b = 680.8; t = 2.688), suggesting that their direct benefits are associated with the presence of *Fortune* headquarters.

In addition to the lagged endogenous terms, a favorable climate, air flights, *Fortune* 500 headquarters, university R&D and military R&D still contribute to high technology industry job growth. The strongest standardized coefficients in this equation are the endogenous lag term (-.76), *Fortune* 500 headquarters (.49), and air flights (.35) followed by technology grant and loan programs (.24), military R&D and climate (both .16), and research parks (.15), indicating that agglomeration factors are the dominant forces behind high technology growth. These factors add 36.3 percent in explained variance to the base model. Removing population density and population change from this equation does not affect any of the other results.

Do these programs magnify or compensate for the agglomeration factors? To examine this, we test interaction terms between our seven policy measures and our agglomeration factors. We also include interactions with daily air flights (a facilitator of agglomeration, see Irwin and Kasarda 1991), population density, and 1988 high technology employment along with the major agglomeration measures. Since population change is an exogenous control, it is not combined in interactions but is retained as a control in the models. If the interaction term is positive, policies are *magnifying* the agglomeration effect by creating greater positive change in high technology industry job growth. If the interaction is negative, policies are *compensating* for lower levels of agglomeration by generating high technology employment growth. In addition to significant interaction terms, the main effects may remain significant, indicating that a policy or agglomeration factor has a direct effect in addition to its contribution in a significant interaction term (see Jaccard, Turrisi and Wan 1990; Aiken and West 1991). If only the interaction term and neither of the main effects are significant, the policy benefits are limited to specific agglomeration contexts. We use centered measures throughout to reduce multicolinearity between the main effects and the interaction terms (Aiken and West 1991: 32-35). We add each interaction term separately to the variables in Model 6 of Table 6 with the other policy measures removed to reduce the risk of multicolinearity. Model 7 in Table 6 shows the first of these 42 equations. To save space, Table 7 summarizes the results, presenting only the coefficients, standard errors and T-statistics for the interaction terms and for the main effects plus the adjusted R^2 (full equation results are available from the authors).

(Table 7 about here)

With the exception of SBIRs that do not produce significant interactions, all of the high technology policies have an impact in at least two or more contexts. In several of these equations, the main effect for policy is not significant, indicating that the agglomeration context specifies the setting where these policies are more effective. In others, both main effects and the interaction term is positive, indicating that the policy and the agglomeration context continue to have effects in addition to the combination of policy with the context.

Public venture capital programs had no statistically significant effects in our earlier equations but these programs contribute to high technology industry employment growth in all of our agglomeration contexts, including more densely populated MSAs. In MSAs with significant military R&D, these programs help compensate for agglomeration deficits. Four of these contexts—air flights, *Fortune* 500 headquarters, military R&D and existing high technology industry—are additively significant alongside the interaction effect.

High technology grant and loan programs interact positively with all the agglomeration contexts and, in five of these contexts, work additively in addition to interactively combining with agglomeration contexts to boost high technology industry employment. *Fortune* 500 headquarters and initial high technology industry employment also work additively in these equations. Overall, grant and loan programs appear to be one of the most consistently beneficial high technology policies.

Technology development programs interact negatively with several agglomeration contexts, indicating contexts in which these programs compensate for agglomeration deficits. Negative interactions with air flights, population density, *Fortune* 500 headquarters, and initial high technology industry employment indicate that technology development programs are compensating for initial agglomeration deficits in these contexts. The main effects for air flights, *Fortune* 500 headquarters, university R&D, and military R&D are positive in these equations, indicating that these factors still contribute to high technology industry employment growth.

Technology deployment and transfer programs are not statistically significant in the earlier equations but they do increase high technology industry employment in conjunction with private venture capital and initial high technology industry employment. Since these programs do not generate new technology but rather attempt to insure that "state of the art" technology is being utilized, this suggests that these contexts maximize the employment benefits of technology deployment and transfer programs by accelerating the adoption of current technology. In both contexts, the main effect of the agglomeration context is also statistically significant.

The two strongest “technopole” factors—technology business incubators and research parks--contribute to high technology job growth in all agglomeration contexts except for military R&D centers for incubators. In the incubator equations with air flights and *Fortune* 500 headquarters, the main effect of incubators is negative and significant, suggesting that incubators do not stimulate high-technology employment growth outside of MSAs with air hubs and *Fortune* 500 headquarters. Both “technopole” policies, the main effects of air flights, *Fortune* 500 headquarters and initial high technology industry employment also retain their statistical significance in these interaction equations.

Overall, these interactions indicate that both the infrastructural and entrepreneurial strategies are conditioned in their effects by the presence of agglomeration advantages. The critics of high technology policy are correct that high technology development is an organic process that cannot be planned from scratch. Existing agglomeration advantages are important to securing benefits from these policies. In a few contexts, policies compensate for agglomeration deficits. At the same time, the limits of these technology policies should not be overstated. Some of these policies—technology grants and loans, incubators, and research parks—have independent effects net of favorable agglomeration contexts and interactions among these. The best formula appears to be using both infrastructural and entrepreneurial policies by adapting them to complement existing local innovation capacities, thereby magnifying the effects of agglomeration advantages. Technology development programs are distinctive in compensating for agglomeration deficits. We find no evidence that the centralized or the decentralized approach is inherently superior. Multiple policies drawing on both approaches are effective, especially when they complement existing high technology resources or compensate for initial disadvantages.

CONCLUSIONS AND IMPLICATIONS FOR POLICY

Our results support the argument that federal, state and local high technology policies are contributing to high technology development and the creation of "good jobs." Although in compositional terms, high technology industry employment did not grow as rapidly as other industrial sectors during the 1988-1998 decade, it is a major source of "good jobs" that pay a third or more greater than jobs in other industries and is a central motor of national economic growth. States and localities in partnership with federal programs have initiated a range of new programs to enhance local innovation capacity and to create new "technopoles" in specific locales.

Of these new high technology policies, technology grant and loan programs and research parks have been the most effective in promoting high technology industry employment growth. Technology grant and loan programs represent the core of a decentralized entrepreneurial approach, funding the development of new products and associated technologies proposed by existing enterprises and would-be entrepreneurs. Research parks represent the core of a centralized "technopole" approach that provides infrastructure for the creation of new high technology industry. By drawing on both approaches and recognizing the need for policy to complement existing agglomeration advantages, states and local governments have increased high technology industry employment.

Our results support the idea that high technology development is an organic, path-dependent process while, at the same time, showing that governmental planning can accelerate this process. The major driving forces behind high technology development are underlying location and agglomeration factors, especially *Fortune* 500 headquarters, air hub centrality and university/military R&D. High technology policies independently have only a modest effect on high technology industry growth. At the same time, several of these policies work independently and interactively with existing agglomeration advantages. In this sense, high technology development can be planned. This planning process needs to take into account existing locational and agglomeration strengths and deficits. While we have not examined the details of this planning process, it is clear that high technology programs need to be adapted to the existing mix of high technology industry, locational and agglomeration resources. Processes that facilitate this policy adjustment, such as industry-government advisory boards, the use of nonprofit corporations and other policy tools, may contribute to policy effectiveness. High technology industry cannot be created entirely from scratch but, at the same time, it can be aided by effective policy.

Our results also suggest specific ways that these policies work. Business incubators attempt to create new enterprises that eventually mature and relocate nearby. While business incubators do not have direct effects net of controls for locational and agglomeration factors, they do magnify the benefits from favorable agglomeration contexts, including the initial level of high technology industry. The lack of a favorable interaction with military R&D probably reflects the national security constraints that have traditionally restricted commercial spin-offs from military R&D facilities. The recent establishment of business incubator programs at several military R&D labs and relaxed commercialization restrictions on military research may alter this in the future.

Public venture capital programs attempt to reduce the capital gap for risky new enterprises by investing state funds (including employee pension funds) in new companies and products on an equity, royalty or convertible debenture basis. These programs do not directly contribute to high technology growth by themselves but, in favorable agglomeration contexts, boost high technology employment. Most states have a single public venture capital program headquartered in or nearby the state capital, raising the possibility that these programs have direct benefits throughout the state rather than in the immediate MSA in which they are located.[8] Further analysis at a state level is needed to assess this possibility.

Technology development programs attempt to spin off new technologies from basic research for eventual commercialization. Partially reflecting the long lead-time required and the geographic portability of new technical knowledge generated in these types of programs, these programs do not have significant additive effects. They do, however, compensate for initial deficits in high technology agglomeration resources.

Technology deployment and transfer programs are designed to make "state of the art" technology available to existing industry. Unlike these other programs, their object is to insure that the best available technology is utilized instead of generating new technologies. In view of this limitation, it is not surprising that these programs do not independently generate high technology employment growth. Nonetheless, in MSAs with greater private venture capital firms and prior concentrations of high technology industry, these programs have positive effects on high technology industry employment growth.

The conventional debate over infrastructural vs. entrepreneurial approaches to high technology development appears misguided. Some have argued for major infrastructural initiatives to create "technopoles" and new "Silicon Valleys." Critics correctly point out that this strategy is unlikely to work by itself and that the informal networks, entrepreneurial traditions, skilled labor and tacit knowledge bases that are critical to high technology development cannot be planned. However, government policies can nurture these local contexts where agglomeration processes are already in place. Hence a "technopole" strategy has to be adapted to fit the local strengths and weaknesses of existing high technology resources. At the same time, this approach needs to be balanced by more decentralized policies, such as public venture capital and technology grant and loan programs that depend on the initiative of existing enterprises and would-be entrepreneurs.

We also find support for existing arguments about the importance of location and agglomeration advantages. Numerous studies have discussed the importance of the R&D spillovers from large *Fortune* 500 companies, research universities and military research labs (Markusen et al. 1986; Saxenian 1994; Kenney 2000; Lee et al. 2000; Hooks 2003; Goldstein and Renault 2004). Others have pointed to the advantages of a good climate (Markusen et al. 1986) and centrality within the air transport system (Irwin and Kasarda 1991). Much of this literature has relied on case studies to demonstrate the plausible link between existing public and private sector R&D and the creation of new high technology firms, patents and regional industrial clusters. Little of this work has used systematic comparison and multivariate controls. Our contribution has been to use these techniques to gauge the relative contribution of these factors on high technology employment growth. Local agglomeration networks and institutions create local capacities for innovation that are central to high technology development. In this sense, high technology industry is locality based. It requires a local innovation capacity that sustains the continuous creation of new enterprises and technologies, including business restarts and the recycling of technology. At the same time, policies adapted to complement existing high technology strengths may magnify the benefits of these advantages and, for technology development policy, compensate for initial agglomeration deficits.

Do these policies constitute a sharp break with traditional industrial recruitment policies? Many analysts have promoted the new technology policies as alternatives to traditional industrial recruitment, arguing that they allow states and localities to "grow their own" new industry (Osborne 1988; Eisinger 1988; Clarke and Gaile 1989, 1998). In this sense, these policies parallel the adoption of export-led development strategies in less developed countries in which the state plays an entrepreneurial function by directly intervening to promote new technology and industrial development (Evans 1995). High technology programs do differ from traditional industrial recruitment in requiring greater targeting and direct participation by state and local governments in the development of new technology, products, markets and enterprises. Yet this distinction should not be overstated. The benefits of these policies depend on favorable agglomeration contexts. High technology policies helped build on existing high technology industry and, for the most part, do not create new industries from scratch. In this sense, high technology policies may be seen as a more sophisticated form of industrial recruitment and retention, allowing areas with existing agglomeration and location advantages to capitalize on their assets. Future research should examine the overall effects of growing inequalities in agglomeration advantages and the policy options for addressing the new inequalities associated with regional disparities in high technology development.

Table 1. High Technology Industry Employment Change, 1988-1998.

Top 20 High Technology Industry Job Gainers:

MSA Name	**# High Tech. Industry Jobs 1988**	**High Tech. Industry Jobs 1998**	**Change High Tech. Industry Jobs 1988-1998**
1. Chicago IL	73,115	302,108	128,993
2. Washington, DC-MD-VA	191,979	288,469	96,490
3. Boston-Lawrence-Salem MA	290,423	350,583	60,160
4. Houston TX	83,822	139,978	56,156
5. Rochester, NY	19,976	75,063	55,087
6. Atlanta, GA	93,750	144,485	50,735
7. Portland OR	40,295	83,865	43,570
8. Dallas, TX	151,510	192,682	41,172
9. New Haven-Waterbury-Meriden CT	34,226	74,514	40,288
10. San Francisco CA	56,315	95,674	39,359
11. San Jose CA	267,542	302,176	34,634
12. Minneapolis-St. Paul, MN-WI	130,077	160,211	30,134
13. Oakland CA	67,746	95,993	28,247
14. Newark NJ	57,338	85,200	27,862
15. Austin, TX	35,568	62,679	27,111
16. Dayton-Springfield, OH	28,846	52,912	24,066
17. Raleigh-Durham, NC	36,191	59,426	23,235
18. Salt Lake City-Ogden, UT	29,535	52,679	23,144
19. Wichita, KS	6,399	28,422	22,023
20. Cleveland OH	70,744	91,438	20,694

Top 20 High Technology Industry Job Losers:

MSA Name	**# High Tech. Industry Jobs 1988**	**# High Tech. Industry Jobs 1998**	**Change High Tech. Industry Jobs 1988-1998**
1. Los Angeles-Long Beach CA	499,945	351,000	-148,945
2. Detroit, MI	258,553	121,456	-137,097
3. Seattle WA	148,797	97,474	-51,323
4. Hartford-New Britain-Middletown CT	79,946	39,580	-40,366
5. Nassau-Suffolk NY	119,528	80,212	-39,316
6. Bergen-Passaic, NJ	82,559	55,008	-27,551
7. Baltimore, MD	66,927	46,312	-20,615
8. Flint, MI	34,953	15,879	-19,074
9. Fort Worth-Arlington, TX	65,762	47,703	-18,059
10. Lansing-East Lansing, MI	23,905	7,523	-16,382
11. St. Louis, MO-IL	112,196	95,883	-16,313
12. Allentown-Bethlehem-Easton, PA-NJ	25,464	9,819	-15,645
13. Saginaw-Bay City-Midland, MI	18,500	5,041	-13,459
14. Peoria, IL	16,364	3,106	-13,258
15. Buffalo-Niagara Falls, NY	35,614	23,262	-12,352
16. Binghamton, NY	15,501	4,178	-11,323
17. Ann Arbor MI	28,096	17,289	-10,807

18. Syracuse, NY	23,618	13,430	-10,188
19. Richland-Kennewick-Pasco, WA	12,420	2,864	-9,556
20. Melbourne-Titusville-Palm Bay, FL	39,269	29,762	-9,507

Table 2: High Technology Programs Inside and Outside of MSAs, 1990.

	# Programs in MSAs	# Programs Outside MSAs	Total Programs
Public Venture Capital	20	2	22
SBIRs	17	9	26
Technology Grants & Loans	16	5	21
Technology Development	94	15	109
Technology Deployment/Transfer	77	23	100
Technology Incubators	137	41	178
Research Parks	99	18	117
Total	460	114	573

Table 3. Top 10 MSAs in Total Cumulative Years of Experience with High Technology Programs, 1990.

Public Venture Capital Programs:

Boston-Lawrence-Salem-Lowell MA	19
Albany-SchenectadyTroy, NY	8
Hartford-New Britain-Middletown CT	8
Madison, WI	7
Indianapolis, IN	7
Lansing-East Lansing, MI	7
Philadelphia, PA	6
Allentown-Bethlehem-Easton, PA-NJ	6
Portland OR	5
Little Rock AR	5

SBIR Programs:

Minneapolis-St. Paul, MN	18
Salt Lake City-Ogden, UT	7
Boise City, ID	7
Houston TX	5
Columbus OH	5
Charleston WV	4
Billings MT	4
Hartford-New Britain-Middletown CT	3
Little Rock AR	3
Baton Rouge LA	2

Technology Grant & Loan Programs:

Little Rock AR	14
Boston-Lawrence-Salem-Lowell MA	14
Indianapolis IN	9
Topeka KS	9
Salt Lake City-Ogden UT	7
Montgomery AL	6
Washington, DC-MD-VA	5
Anchorage AK	4
Austin TX	4
Oklahoma City OK	1

Technology Development Programs:

Raleigh-Durham NC	48
Great Falls MT	29
Detroit MI	23
Lincoln NE	21
Middlesex-Somerset NJ	20
Ann Arbor MI	19
Akron OH	18

Salt Lake City-Ogden UT	16
Orlando, FL	13
Dayton-Springfield OH	12

Technology Deployment/Transfer Programs:

Augusta GA-SC	116
Raleigh-Durham NC	69
Macon-Warner Robins GA	58
Charlotte-Gastonia-Rock Hill NC-SC	43
Atlanta GA	29
Columbus GA-AL	29
Albany GA	29
Athens GA	29
Savannah GA	29
Philadelphia PA	27

High Technology Business Incubators:

Philadelphia PA	43
Pittsburgh PA	41
Buffalo-Niagara Falls NY	25
Chicago IL	22
Minneapolis-St. Paul, MN-WI	16
Boston-Lawrence-Salem-Lowell MA	15
Syracuse NY	15
Toledo OH	12
Albany-Schenectady-Troy NY	10
Dayton-Springfield OH	10

High Technology Research Parks:

Philadelphia PA	43
Oklahoma City OK	40
San Jose CA	39
Richland-Kennewick-Pasco WA	36
Raleigh-Durham NC	31
Washington, DC-MD-VA	30
Lafayette-West Lafayette IN	29
Huntsville AL	28
Champaign-Urbana IL	27
Tampa-St. Petersburg-Clearwater FL	26

Table 6. Unstandardized Coefficients, *Standardized Coefficients* (and Standard Errors) from Regression of High Technology Industry Employment Change, 1988-1998.

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
(Constant)	2448.75	15763.94	1723.27	-1157.83	622.40	2752.32	5319.51
High Technology Industry Employment 1988	-.001 *-.03* (.02)	-.001** *-.24* (.03)	-.18*** *-.50* (.03)	-.19*** *-.51* (.03)	-.081*** *-.21* (.02)	-.28*** *-.76* (.03)	-.29*** *-.80* (.03)
High Technology Industry Wages per Worker 1988	--	-.20** *-.07* (.18)	--	--	--	--	--
Median Housing Cost 1989	--	20.01 *.04* (32.12)	--	--	--	--	--
Climate Index 1988	--	32.83** *.21* (9.36)	--	--	--	25.78** *.16* (7.95)	20.93* *.086* (8.14)
Recreation Index 1988	--	2.14 *.01* (11.27)	--	--	--	--	--
Arts Index 1988	--	-18.80 *-.10* (15.34)	--	--	--	--	--
# Daily Air Flights 1988	--	40.50*** *.43* (7.43)	--	--	--	33.24*** *.35* (6.44)	41.53*** *.44* (6.46)
# Interstates 1988	--	1382.51 *.07* (1324.73)	--	--	--	--	--
# 4 Year Higher Education Institutions	--	-832.11** *-.08* (268.48)	--	--	--	--	--
Percent Black 1989	--	122.68 *.07* (95.14)	--	--	--	--	--
Population Density 1990	--	-.165 *-.01* (1.19)	-2.65 *-.14* (1.42)	-2.31 *-.12* (1.40)	--	-1.58 *-.08* (1.11)	-1.86 *-.10* (1.25)
% Population Change 1990-1997	--	--	--	338.33** *.15* (118.83)	--	200.84 *.09* (110.98)	251.04* *.112* (108.28)
# *Fortune* 500 Headquarters 1988	--	--	1948.68*** *.51* (298.73)	1994.97*** *.52* (295.51)	--	1870.09*** *.49* (280.73)	1929.14*** *.50* (270.08)
# Private Venture Firms 1988	--	--	28.12 *.05* (40.66)	30.54 *.05* (40.17)	--	--	17.61 *.03* (36.98)
University R&D 1990	--	--	.03* *.16* (.01)	.03* *.16* (.01)	--	.01 *.04* (.01)	.003 *.02* (.01)
Military R&D Space Mean 1980/1990	--	--	72.77*** *.21* (19.92)	74.93*** *.22* (19.70)	--	55.45** *.16* (18.46)	78.37*** *.23* (18.07)
Years – Public Venture Capital	--	--	--	--	-597.59 *-.06* (746.18)	438.04 *.04* (659.43)	-292.87 *-.028* (702.52)

Years – SBIRs	--	--	--	--	732.48 *.06* (744.89)	178.42 *.01* (642.47)	--
Years – Technology Grants & Loans	--	--	--	--	2683.97*** *.24* (776.60)	2665.85*** *.24* (660.11)	--
Years – Technology Development	--	--	--	--	-164.21 *-.04* (224.95)	-237.11 *-.06* (195.74)	--
Years – Technology Deployment/Transfer	--	--	--	--	-18.06 *-.004* (95.98)	7.18 *.00* (81.36)	--
Years – Technology Incubators	--	--	--	--	712.30** *.19* (243.87)	134.54 *.04* (217.54)	--
Years – Research Parks	--	--	--	--	483.76** *.20* (153.22)	364.19** *.15* (133.03)	--
Centered Interaction of Public Venture Capital * # Air Flights							11.21*** *.33* (2.33)
Number of Cases	290	290	290	290	290	290	290
Adjusted R^2	.001	.188	.180	.200	.101	.364	.367

*** $p \leq .001$, ** $p \leq .01$, * $\leq .05$ (two-tailed tests); standardized coefficients are in italics, standard errors are in parentheses.

Table 7. Unstandardized Coefficients and Standard Errors from Regression of Policy/Agglomeration Interactions on High Technology Employment Change, 1988-98 (Centered Measures; N = 290).

Interaction Variable	Coefficient	S.E.	Main Effects	Coefficient	S. E.	Adj. R^2
Public Venture Capital:						
Public Venture * Air Flights	11.21***	2.32	Public Venture	-292.86	702.52	.367
			Air Flights	41.53***	6.46	
Public Venture * Pop. Density	3.69***	.872	Public Venture	138.44	681.18	.356
			Pop. Density	-.660	1.304	
Public Venture * *Fortune* 500	408.36***	100.73	Public Venture	177.85	687.26	.352
			Fortune 500	1996.42***	275.25	
Public Venture* Private Venture	109.02***	19.89	Public Venture	420.53	597.38	.381
			Private Venture	52.46	37.11	
Public Venture * Univ. R&D	.009***	.002	Public Venture	-717.495	706.891	.383
			University R&D	.001	.010	
Public Venture * Military R&D	-24.84*	10.359	Public Venture	1920.266***	560.451	.328
			Military R&D	73.008**	18.565	
Public Venture * HT Employment	.019***	.004	Public Venture	-428.978	708.185	.370
			HT Employment	-.289***	.031	
SBIRs:						
SBIRs * Air Flights	7.108	4.18	SBIR	-890.477	1177.481	.298
			Air Flights	34.022***	6.666	
SBIRs * Population Density	2.426	4.047	SBIR	665.235	682.823	.292
			Pop. Density	-1.469	1.580	
SBIRs * *Fortune* 500	74.782	83.790	SBIR	53.790	1039.460	.293
			Fortune 500	1655.715***	286.585	
SBIRs * Private Venture	97.364	91.805	SBIR	545.045	692.303	.294
			Private Venture	27.161	43.039	
SBIRs * University R&D	.003	.006	SBIR	186.075	1081.846	.292
			University R&D	.016	.011	
SBIRs * Military R&D	74.344	77.393	SBIR	630.364	674.995	.294
			Military R&D	78.625**	25.038	
SBIR * HT Employment	.006	.012	SBIR	325.287	1076.721	.292
			HT Employment	-.231***	.032	
Technology Grants and Loans:						
Grants/Loans * Air Flights	17.481***	2.479	Grants/Loans	742.757	598.887	.448
			Air Flights	42.254***	5.993	
Grants/Loans * Pop. Density	5.875***	.940	Grants/Loans	1750.425**	555.282	.429
			Pop. Density	-.539	1.215	
Grants/Loans * *Fortune* 500	707.583***	112.116	Grants/Loans	1877.494***	547.973	.431
			Fortune 500	2297.069***	262.876	
Grants/Loans * Private Venture	135.438***	23.782	Grants/Loans	2202.682***	543.785	.417
			Private Venture	50.214	35.948	

Grants/Loans * Univ. R&D	.011***	.002	Grants/Loans	1228.457*	592.179	.426
			University R&D	-.003	.010	
Grants/Loans * Military R&D	36.485***	7.031	Grants/Loans	2550.785***	539.080	.407
			Military R&D	22.630	18.898	
Grants/Loans * HT Employment	.028***	.004	Grants/Loans	1011.784	599.825	.432
			HT Employment	-.304***	.029	
Technology Development:						
Development * Air Flights	-3.148*	1.385	Development	-6.311	204.309	.302
			Air Flights	33.224***	6.613	
Development * Pop. Density	-2.949***	.473	Development	-103.945	185.515	.376
			Pop. Density	-5.680***	1.368	
Development * *Fortune* 500	-570.350***	73.569	Development	-491.480**	185.289	.415
			Fortune 500	2912.108***	300.355	
Development * Private Venture	.031	5.361	Development	-136.281	198.775	.289
			Private Venture	7.686	40.204	
Development * Univ. R&D	.001	.001	Development	58.133	252.511	.293
			University R&D	.021	.011	
Development * Military R&D	-.334	3.918	Development	-137.179	198.150	.289
			Military R&D	63.644***	24.955	
Development * HT Employment	-.024**	.008	Development	-4.046	198.407	.315
			HT Employment	-.254***	.032	
Technology Deployment/ Transfer:						
Deployment/Trans. * Air Flights	.350	.442	Deployment/Trans	-8.627	82.922	.289
			Air Flights	31.926***	6.831	
Deployment/Trans. * Pop. Den.	.241	.428	Deployment/Trans	21.475	97.745	.289
			Pop. Density	-1.425	1.779	
Deployment/Trans. * *Fortune* 500	9.778	29.826	Deployment/Trans	-1.892	84.815	.288
			Fortune 500	1742.342***	288.231	
Deploy./Trans. * Private Venture	41.696*	16.841	Deployment/Trans	297.067*	147.942	.303
			Private Venture	127.555*	62.422	
Deployment/Trans. * Univ. R&D	.000	.001	Deployment/Trans	-19.006	84.557	.289
			University R&D	.013	.012	
Deployment /Trans. * Mil. R&D	2.863	2.064	Deployment/Trans	11.343	83.845	.293
			Military R&D	52.474**	19.970	
Deployment/Trans. * HT Emp.	.007**	.003	Deployment/Trans	2.461	81.823	.309
			High Tech Emp.	-.225***	.031	
Technology Incubators:						
Incubators * Air Flights	3.335***	.678	Incubators	-555.311*	264.739	.348
			Air Flights	23.818***	6.652	
Incubators * Pop. Density	1.320***	.240	Incubators	-324.054	229.873	.361
			Pop. Density	-2.317	1.257	
Incubators * *Fortune* 500	120.245***	23.260	Incubators	-589.137*	263.161	.354
			Fortune 500	1273.843***	284.530	

Incubators * Private Venture	46.615***	11.967	Incubators	61.525	214.956	.328
			Private Venture	65.971	40.623	
Incubators * Univ. R&D	.005***	.001	Incubators	-469.760	261.827	.341
			University R&D	.007	.011	
Incubators * Military R&D	-1.732	1.863	Incubators	367.615	238.860	.294
			Military R&D	69.698***	21.550	
Incubators * HT Employment	.007**	.002	Incubators	-209.383	261.297	.315
			HT Employment	-.266***	.033	
Research Parks:						
Parks * Air Flights	2.778***	.687	Parks	173.169	134.926	.342
			Air Flights	22.403***	6.876	
Parks * Pop. Density	1.357***	.263	Parks	234.880	128.240	.364
			Pop. Density	1.778	1.454	
Parks * *Fortune* 500	167.653***	25.233	Parks	75.701	129.276	.399
			Fortune 500	1322.359***	267.656	
Parks * Private Venture	21.845***	4.151	Parks	235.180	127.966	.366
			Private Venture	11.878	36.953	
Parks * University R&D	.002*	.001	Parks	238.215	140.087	.313
			University R&D	.006	.011	
Parks * Military R&D	5.811***	1.276	Parks	153.414	133.998	.352
			Military R&D	-7.726	22.732	
Parks * HT Employment	.010***	.002	Parks	-37.765	134.910	.401
			HT Employment	-.346***	.033	

* $p \leq .05$ ** $p \leq .01$ *** $p \leq .001$ (two-tailed tests).

References

Aiken, Leona S. and Stephen G. West. 1991. Multiple Regression: Testing and Interpreting Interactions. Newbury Park, Ca.: Sage.

Atkinson, Robert E. and Paul D. Gottlieb. 2001. The Metropolitan New Economy Index. Washington, D.C.: Progressive Policy Institute.

Audretsch, David B., Juergen Weigand and Claudia Weigand. 2002. "The Impact of the SBIR on Creating Entrepreneurial Behavior. Economic Development Quarterly 16:32-38.

Bollen, Kenneth A. and Robert W. Jackman. 1985. "Regression Diagnostics." Sociological Methods and Research 13:510-42.

Boyer, Richard and David Savageua. 1989. Places Rated Almanac. N. Y.: Prentice-Hall.

Branscomb, Lewis B. and Richard Florida. 1998. "Challenges to Technology Policy in a Changing World Economy." Pp. 3-39 in Investing in Innovation, ed. by Lewis B. Branscomb and James H. Keller. Cambridge, MA: MIT Press.

Castells, Manuel and Peter Hall. 1994. Technopoles of the World: The Making of 21st Century Industrial Complexes. London: Routledge.

Clark, Marianne. 1986. Revitalizing State Economies. Washington, D.C.: National Governors Association.

Clarke, Susan E. and Gary L. Gaile. 1989. "Moving Towards Entrepreneurial State and Local Development Strategies." Policy Studies Journal 17:574-598.

Clarke, Susan E. and Gary L. Gaile. 1998. The Work of Cities. Minneapolis, MN: University of Minnesota Press.

Chapple, K., Ann Markusen and Greg Schrock. 2004. "Gauging Metropolitan "High Tech" and "I-Tech" Activity." Economic Development Quarterly 18:10-29.

Coburn, Christopher and Dan Berglund. 1995. Partnerships: A Compendium of State Technology Programs. Columbus, Oh.: Battelle Memorial Institute.

Cohen, Wesley M., Richard Nelson and John Walsh. 1996. "Appropriability Conditons and Why Firms Patent and Why They Do Not in the American Manufacturing Sector." Presented at OECD June 1996.

Cortright, Joseph and Heike Mayer. 2002. Signs of Life: The Growth of Biotechnology Centers in the U.S.. Washington, D.C.: Brookings Institution Center on Urban and Metropolitan Policy.

DeVol, Ross, Rob Roepp and Frank Fogelbach. 2002. State Technology and Science Index. Santa Monica, Ca.: Milken Institute (www.milken.org).

Finkel, Steven. 1995. Causal Analysis with Panel Data. Newbury Park, CA: Sage.

Eisinger, Peter. 1988. The Rise of the Entrepreneurial State. Madison: University of Wisconsin Press.

Evans, Peter. 1995. Embedded Autonomy: States and Industrial Transformation. Princeton, N.J.: Princeton University Press.

Florida, Richard. 2002. The Rise of the Creative Class. N.Y.: Basic.

Florida, Richard and Martin Kenney. 1990. The Breakthrough Illusion. N.Y.: Basic.

Fortune. 1989. "Top 500 Manufacturer's." February 1989.

Fujita, Masahisa, Paul Krugman and Anthony J. Venables. 1999. The Spatial Economy : Cities, Regions and International Trade. Cambridge, Ma.: MIT Press.

Goldstein, Harvey A. and Catherine S. Renault. 2004. "Contributions of Universities to Regional Economic Development: A Quasi-Experimental Approach." Regional Studies 38:73-746.

Hadlock, Paul, Daniel Hecker and Joseph Gannon. 1991. "High Technology Employment: Another View." Monthly Labor Review (July) 26-30.

Harchaoui, Tarek M., Faouzi Tarkhani, Chris Jackson and Phillip Armstrong. 2002. "Information Technology and Economic Growth in Canada and the U.S." Monthly Labor Review (Oct.): 3-31.

Hawley, Amos H. 1981. Urban Society: An Ecological Approach. N.Y.: Wiley.

Hecker, Daniel. 1999. "High-technology Employment: A Broader View." Monthly Labor Review (June): 18-28.

Hooks, Greg. 2003. "Military and Civilian Dimensions of America's Regional Policy, 1972-1994." Armed Forces and Society 29:227-45.

Irwin, Michael and John D. Kasarda. 1991. "Air Passenger Linkages and Employment Growth in United States Metropolitan Areas." American Sociological Review 56:524-537.

Jaccard, James, Robert Turrisi, and Choi K. Wan. 1990. Interaction Effects in Multiple Regression. Newbury Park, Ca.: Sage.

Kask, Christopher and Edward Sieber. 2002. "Productivity Growth in "High-Tech" Manufacturing Industries." Monthly Labor Review (March) 16-31.

Kenney, Martin and Richard Florida. 2000. "Venture Capital in Silicon Valley." Pp. 98-123 in Understanding Silicon Valley, ed. by Martin Kenney. Stanford, CA.: Stanford University Press.

Kenney, Martin and Urs von Burg. 2000. "Institutions and Economics." Pp. 218-240 in Understanding Silicon Valley, ed. Martin Kenney. Stanford, Ca.: Stanford University Press.

Koepp, Rob. 2002. Clusters of Creativity. N.Y.: Cambridge University Press.

Kolko, Jed. 2002. "Silicon Mountains, Silicon Molehills: Geographic Concentration and the Convergence of Internet Industries in the U.S." Information Economics and Policy 14:211-232.

Kotkin, Joel. 2001. The New Geography: How the Digital Revolution is Shaping the American Landscape. N.Y.: Random House.

Lee, Chong-Moon, William F. Miller, Marguerite Gong Hancock, and Henry S. Rowen. 2000. The Silicon Valley Edge. Stanford, CA. Stanford University Press.

Leicht, Kevin T. and J. Craig Jenkins. 1994. "Three Strategies of State Economic Development: Entrepreneurial, Industrial Recruitment and Deregulation Policies in the American States." Economic Development Quarterly 8:256-70.

Luger, Michael I. and Harvey A. Goldstein. 1991. Technology in the Garden. Chapel Hill, N.C.: University of North Carolina Press.

Luger, Michael and Harvey A. Goldstein. 1997. "What is the Role of Public Universities in Regional Economic Development?" Pp. 104-134 in Dilemmas of Urban Economic Development, ed. by Richard D. Bingham and Robert Meier. Thousand Oaks, CA: Sage.

Markusen, Ann, Peter Hall and Amy Glasmeier. 1986. High Tech America. Boston: Allen & Unwin.

Minnesota Department of Trade and Economic Development. 1988. State Technology Programs in the United States. St. Paul, Mn.: Minnesota Dept. of Trade and Economic Development.

Morris, Jane K. and Susan Isenstein. 1989. Pratt's Guide to Venture Capital Sources. Wellesly Hills, MA: Venture Economics.

National Science Board. 1998. "Industry, Technology and Competitiveness in the Marketplace." In Science and Engineering Indicators—2002. Arlington, Va.: National Science Foundation.

National Science Foundation. 2002b. "University R&D." Arlington, Va.: National Science Foundation (www.nsf.gov/nsr).

Osborne, David. 1988. Laboratories of Democracy. Boston: Harvard Business School Press.

Riche, Richard W., Daniel E. Hecker and John U. Burgan. 1983. "High Technology Today and Tomorrow: A Small Slice of the Employment Pie." Monthly Labor Review (November): 50-58.

Rogers, Everett M. and Judith K. Larsen. 1984. Silicon Valley Fever. N.Y.: Basic Books.

Saiz, Martin. 2001. "Using Program Attributes to Measure and Evaluate State Economic Development Strategies." Economic Development Quarterly 15:45-57.

Saxenian, Anna Lee. 1994. Regional Advantage: Culture and Competition in Silicon Valley and Route 128. Cambridge, Ma.: Harvard University Press.

Sorensen, Oliva and Pino G. Audia. 2000. "The Social Structure of Entrepreneurial Activity: Geographic Concentration of Footwear Production in the United States, 1970-1989." American Journal of Sociology 106:424-462.

Thornton, Patricia. 1999. "The Sociology of Entrepreneurship." Annual Review of Sociology 25:19-46.

U.S. Congress, Office of Technology Assessment. 1984. Technology, Innovation and Regional Economic Development. Washington, D.C.: GPO.

U.S. Bureau of the Census. 1991. State and Metropolitan Area Data Book 1991. Washington, D.C.: GPO.

U.S. Bureau of the Census. 2000. State and Metropolitan Area Data Book 2000. Washington, D.C.: GPO.

Wallsten, Scott J. 1998. "Rethinking the Small Business Innovation Research Program." Pp. 194-220 in Investing in Innovation, ed. by Lewis M. Branscomb and James H. Keller. Cambridge, MA: MIT Press.

Wolman, Harold and David Spitzley. 1996. "The Politics of Local Economic Development." Economic Development Quarterly 10:115-150.

Zachariadas, Marios. 2002. "R&D, Innovation and Technological Progress: A Test of the Schumpeterian Framework without Scale Effects." Working Paper #2002-18, Dept. of Economics, Louisiana State University (www.bus.lsu/economics/papers/pap02_18.pdf)

Endnotes

1. See also the refinement by Chapple, Markusen and Schrock (2004), which emphasizes the mix of R&D occupations to capture high technology industry.

2. An exploratory principal components analysis of the first difference change scores for MSA high technology employment using the three measures of high technology industry employment proposed by Markusen et al. (1987), Hadlock et al. (1991), Hecker (1999) and Chapple, Markusen and Schrock (2004) loaded on the same vector, indicating that these alternative operationalizations are measuring the same underlying construct.

3. The Standard Industrial Classification codes for high tech industries based on the 1987 Standard Industrial Classification Manual are as follows: 281, 282, 283, 284, 285, 286, 287, 289, 291, 348, 351, 353, 355, 356, 357, 361, 362, 365, 371, 366, 367, 372, 376, 381, 382, 384, 386, 737, 873, 871, and 874 (see Hecker 1999: 20-21).

4. Although the CEW Program (ES-202) does provide county-level employment estimates, which could be used to measure high technology employment in counties that moved in or out of the MSA list due to U.S. Census revisions, we restricted our analysis to those MSAs that were in both the 1980 and the 1990 Census list for several reasons. First, only twenty-two units would be added by this approach, representing less than four percent of total MSA population. Second, the suppression of CEW data at the 3 and 4-digit industry level due to confidentiality disclosure restrictions would make their addition problematic. These are relatively small labor markets with more suppressed employment data, which might introduce error into the analysis. Another possibility is aggregating MSAs to the Consolidated Metropolitan Statistical Area (or CMSA) level. This does not seem advisable, however, because several of our independent measures are not available for CMSA units. Mean values for CMSA units might distort differences between,

e.g. Los Angeles/Riverside CA and Santa Anna (Orange County) CA. We instead used the component PMSA (Primary Metropolitan Statistical Areas), providing more direct measurement of several independent variables. We also tested a dummy variable for PMSA units that were components of CMSAs in our full equation but it was never statistically significant.

5. We also ran these same models using a lagged panel design (i.e. predicting 1998 high technology industry employment net of a control for the endogenous 1988 high technology industry employment), obtaining the same pattern of significant predictors. We present the conditional change results because they provide interpretable partial slopes, standardized coefficients and adjusted R^2 estimates.

6. In addition to log transformations, we also tested dummy variables representing the presence (yes = 1; no = 0) of several skewed independent variables (*Fortune* 500 headquarters, private venture capital firms, university R&D and federal/military R&D) as well as all seven policy measures but the raw scores performed better in the regression analysis. This suggests it is not the simple presence of these policies or agglomeration factors but their magnitude that affects high technology employment change.

7. Detroit is influential outlier due to a large negative change in the number of high technology industry jobs in the auto industry despite the existence of two longstanding technology development programs—the Michigan Energy Research and Resource Association and the Metropolitan Center for High Technology. Both technology development programs were focused on the local needs of the auto industry but during our period corporate restructuring of automotive research and design created a major employment change. We therefore removed Detroit from our regression sample.

8. We also tested dummy interactions between MSA state capitals and cumulative program

duration adding to the base equation in Model 7, finding some evidence of benefits and losses to capital cities. The dummy variable representing state capitals was never significant in this or simpler equations. The dummy interaction was positive and significant for technology incubators but negative and significant for grant and loan programs. None of the other dummy interactions were significant, including that for public venture capital programs. Capital cities may benefit more from incubators in their midst while loosing from grant and loan programs that distribute most of their awards outside the state capital but otherwise there appears to be no special job gain from being a state capital.